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UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Agricultural Economics

THE ROLE OF MACHINERY IN THE DEVELOPMENT OF THE AGRICULTURE OF THE UNITED STATES

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Within a few years after our Republic was founded the cotton gin and iron plow were invented. From that date to the present time there have been continuous developments and improvements of agricultural machinery and equipment. Conditions have been more favorable toward increased machinery use in this country than in the older established countries. Our great national resources included rich productive lands physically adapted to large machinery and through most of the 19th century these lands were available to new settlers practically without cost. Our population was relatively sparse and with industrial demand for labor increasing throughout most of this time farm labor was scarce and wage rates higher than in the old countries. In the new areas farm practices had not become fixed and the size of the farm could be easily expanded to correspond to the capacity of new machines. It is normally in the newer areas that conditions are most favorable for a rapid expansion in machinery use. This report covers some of the major developments which have taken place in agricultural machinery and equipment throughout the 19th century and up to the present time.

Through the Nineteenth Century

At the beginning of the 19th century the farmers of this country and in fact, farmers the world over, were still using about the same methods for planting, cultivating, and harvesting their crops as had been practiced for centuries with but slight modification.

The best plows at the beginning of the 19th century were crude, wooden affairs. In some sections the plow was little used, the land being prepared for seeding crops by hand tools. Wheat and small grains were sowed broadcast by hand. Crops like cotton and corn were planted by dropping the seed from the hand and covering them with a hoe. Crops were cultivated and harvested entirely by hand methods. The wagon and cart of the 19th century were decidedly cumbersome vehicles made entirely of wood.

Crude as were the implements used by the farmers of Europe at the beginning of the 19th century, even less efficient were the implements used by the early settlers of the United States. Transportation methods in that day were slow and costly. Little material was available to the early colonists for making their own implements and in many instances there was an actual shortage of even these inefficient implements.

The invention of the cotton gin, shortly after the close of the Revolutionary War, marked the beginning of an era that brought great improvements in farm machinery and in production methods.

The iron plow came into use in this country soon after the beginning of the 19th century. Thomas Jefferson was one of the first to design such a plow. The cradle, the threshing machine, and the hay rake were developed about this time and improvements in these and other implements for planting, cultivating, and harvesting crops were soon forthcoming.

The settling of the central part of the United States brought into cultivation vast areas of fertile, level lands admirably suited for grain production and the effective use of large machinery. At this time there was an ever-increasing demand for grain for export. These conditions, together with the scarcity and relatively high cost of labor, resulted in a greatly increased demand for large machinery. This demand was supplied by the ingenious inventors of that time, and the 25-year period ending with the Civil War witnessed many developments and improvements of agricultural machinery.

During the Civil War period exports of grain continued about normal although more than one million men were removed by the war from northern farms alone. This was possible because of the greatly increased use of machinery. It was then that the grain separator, reaper, mowing machine, steam tractor, and many other machines were developed or greatly improved.

The increase in the use of machinery during the 19th century did not take place without the necessity of overcoming many difficulties. When the iron plow was first introduced there were many farmers who contended that it would poison the soil. Many poorly designed and costly machines which could never be operated to advantage were sold to farmers. Farmers soon began to demand practical field demonstrations before purchasing new machines. As a result, demonstrations and field tests were in evidence during the periods of great development of farm machinery.

During the Twentieth Century

It was after the middle of the nineteenth century that our manufacturing industries were mechanized and organized so that the advantages of large-scale production could be obtained. Since that time, in most industries, there has been a continuous upward trend in the output per worker. Data that will afford exact measures are not available, but it has been estimated that the output per worker in manufacturing increased from 50 percent to 100 percent, from 1870 to 1920. In agriculture the increase was in about the same proportion. Recent indications are that in many industries and in agriculture gains in efficiency have been greater from 1920 to 1930 than in any previous decade.

This increase in the use of machinery has been accompanied by a large increase in the amount of primary power on farms. It has been estimated that in 1850 the primary power on farms was about 6 1/2 million horse power, while in 1930 it was about 70 million horse power, representing about a 10-fold increase. If the number of workers quadrupled in this period, there was more than twice as much power per worker in agriculture in 1930 as in 1850. The increase in power on farms has been especially rapid since the advent of the gasoline tractor and motor truck.

In agriculture as in industry, the use of machinery and power has played an important role in increasing the worker's efficiency. Reports of the agricultural census give the value of all implements and machinery on farms in 1850, at about 150 million dollars; and,in 1930, place the value at more than 3,300 million dollars. The area in farm land was greatly increased during this period, but the number of workers engaged in agriculture in 1930 was only 3 to 4 times as great as in 1850. Thus it is apparent that the average agricultural worker in the United States is now using several times as much machinery as did the average worker of 1850.

Gasoline tractors first came into use about a decade before the beginning of the World War. The use of motor power and of large farm machinery in general was greatly stimulated during the World War when prices of farm products soared and labor was scarce and wage rates greatly increased over pre-war levels. After the close of the war, the tendency toward the greater use of machines continued until 1930 since farmers found that machinery, effectively used, makes for low production costs.

Other Influences at Work

Some of our increase in productivity has resulted from general improvements in production practices. The development of better yielding varieties of many of our crops as well as increased and more intelligent use of fertilizer along with the development and wider use of better cropping systems has resulted in larger yields for many of our crops. For example, apple production at the present time is about the same as in 1916, although the number of bearing trees decreased more than 40 percent during this period. There has been a marked tendency to concentrate the production of the different crops and kinds of live-stock in areas where conditions are most favorable.

Machinery Releases Farm Workers

In 1870, of our people 10 years of age and older engaged in gainful occupations, about 47 percent or about six million were employed in some phase of agriculture, whereas in 1930 less than 22 percent of the workers of the country, or about 10½ millions, were employed in agriculture. In this same period the production of our principal cereal crops has increased from 200 percent to 300 percent, cotton about 300 percent, sugar about 200 percent, and even greater increases are recorded for some of our more intensively cultivated crops. The increase in productivity per worker in agriculture from 1870 to 1920 is estimated at 75 percent to 100 percent.

Along with the constantly increasing use of labor-saving machines and power on the farms in the United States has come the transfer to the city of many activities formerly conducted on the farm. The farmer of a century ago,

in addition to producing his crops and livestock, prepared many of his products for consumption. He made his own implements and from the forest obtained and processed the materials for his buildings. In his own home, wool and other fibers which he produced were made into clothing for the farm family. For a century there has been a continuous shifting of activities from the farm to the factory, and now farmers devote most of their efforts to producing crops and livestock for sale. Grain, wool, fiber crops, meat animals, and much of the livestock products are prepared and processed in industrial plants often located in large cities and at a long distance from the producing sections. Farm implements and machines are all produced in large factories.

Machinery in Wheat Regions

The development and widespread use of large-sized machines for harvesting the wheat crop illustrates in a striking way the contribution of machinery to agriculture in the United States. Before the 19th century wheat and other small grains were harvested with a sickle and threshed with a flail. The first improvement of importance was the cradle which came into general use at the beginning of the 19th century. The reaper, invented in 1833, was the first machine to make use of animal power in harvesting, and by 1860 its use had become so general that it was an established farm implement. Improvements in the reaper were rapidly forthcoming and the twine binder was placed on the market in 1878. The bundle carrier was later added, thus completing the binder machine that is in common use today.

The first threshing machine came into use immediately following the introduction of the cradle and by 1840 nearly all wheat grown in the principal wheat sections was being threshed by machine. Grain separators came into use about 1850.

The establishment of wheat production in the sub-humid areas, where the straw was sometimes too short to permit of using the binder to advantage and where the moisture content at harvest time is low enough to permit stacking as the grain is cut, was largely responsible for bringing the header into use. It was used in the Pacific Coast States as early as 1870.

The combined harvester-thresher, commonly called the combine, was used along the Pacific Coast for some time prior to 1900. For years it was used exclusively in this district where weather conditions are especially favorable for combining the grain. At this time it was believed that the combine was unsuited for harvesting wheat in localities where rainfall is more or less frequent during the harvesting period. However, combines finally came into limited use in the Great Plains area between 1915 and 1920, and since then they have increased rapidly and extensively and their use is now well established.

The first combines of the Pacific Coast region were operated by large-sized teams but the combines of the Great Plains region of today are operated by motor power. The combine has spread rapidly over the principal wheat-producing areas and, at present, is used to some extent in every important wheat-producing State. Kansas was reported to have had 8,274 combines in 1926; in 1930 this number had increased to about 21,500. It is estimated that more than 40 percent of the 1930 harvested wheat acreage was combined. The use of the combine was largely confined to the drier wheat producing areas but in the Corn Belt and other humid areas, some combines were reported.

The improvements in machinery have resulted in a great saving of farm labor. When wheat was harvested with a sickle and threshed with a flail, from 35 to 50 hours of labor were necessary for harvesting and threshing an acre of wheat with a yield of 15 bushels. The introduction of the cradle effected a saving of about 10 hours per acre. At present, farmers in the Great Plains usually use from 4 to 5 hours of labor for harvesting and threshing an acre of wheat when it is harvested with a binder and threshed from the shock with a stationary thresher; from 3 to 4 hours of labor, when the crop is harvested with a header and threshed with a stationary thresher; and an average of three-fourths of an hour of labor when the combined harvester-thresher is used. Stated in another way, a combined harvester-thresher usually harvests and threshes wheat at a cost of about $1.50 per acre while the cost when the header or binder is used, is usually about double this figure.

The development of newer methods of harvesting and threshing, along with the improvements in machinery, has furthered the movement towards large-sized farms. Prior to the advent of the header and binder the production of small grain crops did not assume a specialized role in American farming. In the Great Plains region from 125 to 175 acres of wheat can be harvested per season with a seven-foot binder; from 300 to 400 acres can be handled with a twelve-foot header while a sixteen-foot combine operated by an auxiliary engine can handle 600 acres per season. The resulting movement towards large-sized farms is strikingly illustrated in Montana. In that State there were 35,000 wheat farms in 1917. Many of these farmers operated units of 320 acres or less. It is estimated that in this State in 1930 there were 14,000 wheat farmers who operated more wheat land than did the 35,000 farmers of a decade earlier.

Machinery in Rice Regions

Rice growers, as a whole, use tractor-drawn machinery to a greater extent than any other class of farmers in the United States. As early as 1920, tractors were extensively used by rice farmers of the leading producing districts. In the principal rice-producing county of Arkansas one or more tractors were reported on practically every farm in 1928. On these farms, tractors are used to a considerable extent for preparing the seed bed but are used chiefly for harvesting. The development of the power take-off has been of especial value to rice growers. Prior to this development binders for harvesting rice were usually equipped with auxiliary gas engines as they could not otherwise develop sufficient tractive power under field conditions.

American rice growers of the prairie regions, who use tractors for harvesting and to some extent for preparing and seeding the crop, and who thresh their grain with a stationary thresher, usually use less than 5 days of labor for growing, harvesting, and threshing an acre of rice yielding 50 bushels. In China where small-sized machinery, operated by animal power, is used, and where the crop is harvested with a sickle and threshed by hand methods, about 50 days of labor is used for growing, harvesting and threshing an acre of rice yielding about 50 bushels.

Machinery in Cotton Regions

The invention of the cotton gin at the end of the 18th century resulted in the establishing of cotton as a major crop in the United States. Prior to this, the seed and lint were separated by hand methods. Cotton goods, it has been said, were often more expensive at that time than woolens and it is reported that the latter were often made of imitation of cotton fabrics to increase their value. From this time until recent years there were no developments in machinery which materially contributed to cotton production.

Widespread infestation of the Cotton Belt by the cotton boll weevil reduced the size of the cotton crop in the United States from 1921 to 1923 to such an extent that prices became exceptionally high. As a result of these prices the Cotton Belt was greatly expanded. It is in the new cotton areas of western Texas and Oklahoma that machinery first played an important role in the growing of cotton. In these new areas conditions were favorable for the growing of large acreages. Weed control, an item of vital importance to growers further east, is relatively unimportant in these new areas where weeds are few. Many farmers in this new cotton country were formerly ranchmen who had large acreages of level land at their disposal. It was in this new section of the cotton country that the general-purpose farm tractor was first extensively used in the growing of cotton.

Large-sized machinery, such as two row listers and cultivators of equal size have come into general use, especially in the more nearly level areas of this new cotton section. New methods of harvesting have been developed in this new cotton country. For some years growers have made it a general practice to harvest by snapping or hand-stripping, a considerable part of the crop that remains in the field after killing frosts have occurred. In 1926, a year of low cotton prices and relatively high labor costs the practice of snapping gave way to a method of harvesting known as sledding. The sled or stripping machine is now used only to a limited extent in these western areas.

By using labor and machinery effectively, growers in these new areas are able to produce much larger acreages of cotton than can growers of the older and more established cotton-producing areas. A farm family in this new cotton country often grows from 100 to 200 acres of cotton, using extra labor only for harvesting the crop. In a representative cotton county of western Texas an average of about 80 acres of cotton was reported for each cotton farmer. In the old Cotton Belt the farm family usually plants from 10 to 30 acres of cotton and about the same acreage of other crops. Growers in these new areas are able to produce an acre of cotton yielding 150 pounds lint with from 30 to 50 hours of labor. About 100 hours of labor are usually necessary for producing an acre of cotton of this yield in the older areas.

In the old Cotton Belt much migration of colored labor and abandonment of farms was reported from 1920 to 1930. The cotton boll weevil was largely responsible for this condition but the opening up of new cotton areas, where machinery could be used to advantage for producing cotton and where cotton could be produced at a lower cost than in the older areas, also contributed to this development.

Development and Use of the Tractor

The gasoline motor has been the most important addition to agricultural machinery in the United States since the beginning of the 20th century. However, machine power first replaced animal power for plowing land as early as 1858, when steam engines of large size, equipped with gang plows demonstrated their ability to plow land at the rate of 60 acres per day. The first steam engines were of two types; movable and stationary. With the stationary type, the plows were pulled through the fields by means of a wire cable attached to a windlass. Steam engines were probably first used for plowing in the northern States. Later they came into more general use in the Great Plains region and Pacific Coast States.

During the first decade of the 20th century the gasoline tractor was going through a development period and was used by farmers only to a limited extent. The first gasoline tractors were used principally for plowing and discing; they were most common in the Wheat Belt. The first tractors tended to be of rather large size since they were used chiefly for heavy work. General-purpose tractors designed for cultivating, as well as for plowing and other light draft operations, came into limited use about 1915. Since 1920, especially from 1925 to 1930, the development of the general-purpose tractor has been rapid.

In 1917, about 60,000 tractors were manufactured in the United States which was an increase of about 100 percent as compared with the turnout of the previous year. There were more than 900,000 tractors on farms in the United States in 1930. Some farms, largely located in the more favored areas in the Wheat Belt, Corn Belt, and the Cotton Belt, are entirely operated by motor power.

Most of the types of machines now in use on farms in the United States were well established before the gasoline tractor assumed a role of importance. The extensive use of tractors during recent years has, however, resulted in large machinery coming into more general use. Many farmers have replaced one and two-horse implements with large-size horse implements or with tractor-operated machines. For more than 30 years the duck-foot cultivator has been used to a limited extent, at least along the Pacific Coast. Recently it has been successfully introduced in the Wheat Belt of the Northern Great Plains where it is used for summer fallowing and preparing land for small grains.

Some new machines have been developed with the increased use of tractors. The three, four, and six-row cultivators and the three and four lister planter are examples of such machines. The power "Take-off" is also a recent development of importance.

Use of Animal Power Decreases

The increased use of tractors together with an even greater increase in the use of automobiles and trucks has resulted in a decrease in the number of horses and mules kept on the farms and cities of the United States. From 1920 to 1930 horses and mules in the United States decreased from about 28,000,000 to less than 20,000,000, a decline of about 29 percent. The replacement of work animals with tractors, trucks, and automobiles, has caused

some mal-adjustment in our agricultural production in that there are now available for other uses from 30 million to 40 million acres of crop land which a decade ago was needed for producing feed for horses and mules. For example, producers of timothy hay, who a decade ago had a well established market for their produce now find it difficult to dispose of it at prices sufficient to cover production costs. A similar situation presents itself with reference to oats and other feed grains. Unless new uses for feed grain and hay are forthcoming it will apparently be necessary for producers to reduce the acreage of these crops permanently in order to adjust production to the declining demand.

Hand Labor Used for Certain Crops

Although machinery has contributed much to the development of agriculture in the United States, growers of the various crops have not shared equally in these improvements. Producers of grain and forage crops have benefited to a much greater extent than have other producers. At the present time it is a common practice among the producers of some of our important crops to use small size machines and to do much of the work by hand methods. This applies particularly to the cotton farmers of the older areas, the tobacco farmers, the sugar beet farmers, the truck farmers, and to producers of small fruits. In the growing of these crops much hand labor is still used, especially for harvesting and weeding, and the acreage planted largely depends on the labor available for performing these operations. Large size machines are used to a limited extent in the growing of sugar beets. The bulk of our tobacco and truck crops and much of our cotton, even now, are grown on small farms. On many of these farms the use of large machinery would usually be uneconomical in that its cost would be greater than the saving effected.

The cotton, tobacco, and truck farmers of the South have long had an abundance of cheap labor at their disposal; whereas, in the grain sections, labor has usually been scarce and wages relatively high. The rural negro population is largely concentrated within the southern States. They work for relatively low wages since the cost of living is lower than in the northern States. Under the share cropper system, which has long held sway in the South, the increased use of machinery would not increase the planters' returns since this item of cost was usually borne by the land owner. When a planter procured additional land it was his policy to obtain more workers rather than to purchase larger machinery.

It has long been claimed that the negro labor of the South could not handle large machines to advantage. The statement now appears to have been erroneous inasmuch as this negro labor has been used to advantage in industrial centers to which large numbers have migrated in recent years. Since this migration there has been a decided tendency toward the increased use of large machinery even within the old Cotton Belt. The small machinery and the production methods of the South appear inefficient when compared with the better sections of the wheat and corn belt. Nevertheless southern farmers use larger scale production methods than do producers of the same crops in other lands.

Family and Social Benefits

At the same time that machinery has greatly increased the production of our agricultural workers, it has contributed in other ways to improving conditions on the farm. Many of our farmers now use machines for work which was formerly done by hand or with implements which required great physical effort. Less than three-quarters of a century ago the possession of great physical strength was a decided asset to a farmer. The working day on the farm was then of long duration especially during the harvest season. The saving in time and labor effected by machinery has appreciably shortened the working day of the farmer. The farmer of today who uses machinery accomplishes more during a given period than in the past and with much less physical effort.

In our farming areas where labor-saving machinery has come into general use, the women and children do much less farm work than on farms where machinery has played a role of less importance. At the beginning of the 19th century the farmer marketed little except what his own labor and that of his family produced. This is true even now in some sections. In harvesting tobacco, cotton, small fruits and truck crops, 75 percent of the work is often done by women and children. But with the grain farmer and many other farmers who use machinery extensively, the use of women and children for performing farm work has steadily declined.

Thus a study in a typical section of the Wheat Belt showed that the farm family, exclusive of the farm operator, did on the average less than six months of farm work per farm, while in tobacco production along the Atlantic Coast, where little improved machinery is used, the farm family contributed annually on the average, the equivalent of 10 months work for one man. Gross sales per farm averaged about $4,500 in the Wheat Belt and less than $1,500 per farm in the Tobacco Belt. To be sure, $4,000 to $5,000 are required to equip a farm properly in the Wheat Belt with new machinery while the tobacco producers had on the average about $300 worth of machinery per farm. But the wheat producers have an output that is large enough to pay for the use of machinery, and all the other expenses of farming, and still have a much larger net income than do the tobacco farmers.

In farming sections where machinery is not extensively used, only too often even now the children are kept from school to work on the farm. As a result they do not obtain education equal to that of farm children in sections where machinery is extensively used.

The farm home has also benefited from machinery development. Spinning and weaving, which a century ago were ordinary household tasks, are now no longer done at home. Many farm homes in every section of the country are now equipped with electric power plants or are supplied with electricity by power companies. The sewing machine, the mechanical washing machine, the water pump, and the cream separator, all of which can be operated either by electricity or by a gasoline motor, are examples of machines which have come into general use and have greatly assisted in lightening the load and shortening the work day of the farmer's wife. On many farms the farm family now enjoys practically the same improvements and advantages as does the city family.

The automobile, the new means of transportation which is now used by all classes of people in the United States, has contributed much toward improving living conditions on the farm. Of the 23,500,000 passenger cars in

use in the United States in 1930 it was estimated that 4,135,000 were owned by our 6,283,000 farm families, who in addition owned 900,000 motor trucks. With the increased use of motor transportation, the country is now in the midst of a period of great improvement in our highway system. The farmer with an automobile is no longer isolated; recreational centers, churches and markets which were formerly far removed are now easily accessible.

American Conditions were Favorable

The social and economic conditions which have prevailed in many parts of the United States have been especially favorable to the mechanization of farming. In the first place, the farm people of the country have been imbued with a desire to improve their standards of living and they have found that the wise use of machinery helped to increase their incomes. Second, vast areas of land well-suited to the use of machinery have been added to the farm area of the country in the past century through "homesteading" and irrigation, and the greatest development in use of machinery has been in these new sections where production methods had not been firmly established and where the size of farm could be increased easily. Third, the rate of growth of this country, since the beginning of the 19th century, both of its population and wealth has probably never been equalled elsewhere. Natural resources and raw material were abundant and being so were relatively cheap; labor was relatively scarce and expensive. With the continued and uninterrupted growth of this country the labor which machinery displaced both on farms and in factories has been largely absorbed in other rapidly growing industries; and the increased productivity of our workers and the continued improvement in the standard of living for all our people, has made it possible for new and old industries to grow and expand. These conditions have brought forth a constant demand on the part of farmers for labor-saving implements and machines and have furnished a powerful incentive to inventors and manufacturers for improving and developing machines.

Future Trend in Machinery Use

The depression which began in 1929 has been accompanied by conditions which make it difficult to appraise the future trend of use of farm machinery and mechanical power. Continued restrictions in foreign markets, the present tendency to reduce the volume of our agricultural production, and the relatively low prices of farm products make heavy investments in farm equipment unwise in many cases. Further, the advantage in machinery use has been lessened because of industrial unemployment which has released many workers and the population movement from the city to the farm has increased the farm labor supply and the wage rate to farm labor has declined 50 percent or more in many areas.

The tendency toward increased machinery use in this country continued from 1800 to 1930 under conditions which were greatly different from those which now confront American farmers. During the time when machinery use was increasing, there was an increasing demand, both foreign and domestic, for the products of American farms. Prior to the World War the United States was a debtor nation. At that time considerable purchases of our raw materials could be met by foreign countries with interest and other payments which they received from capital investments in this country. During the World War and in the post-war periods, foreign purchases were met to a considerable extent through foreign borrowings. As a result of the World War, the status

of the United States was changed from a debtor nation to a creditor nation. Under present conditions it has become difficult for American producers to find foreign outlets for their surplus products.

In the past, expansion in machinery use on American farms has been greatly increased in certain periods of our history, when conditions were especially favorable for such an expansion and the tendency toward increased machinery use has been checked with the return of more normal conditions.

Thus in the Civil War and World War periods and in the years immediately following these wars, the use of farm machinery was greatly increased. Prices of farm products arose sharply in both periods. Millions of men were under arms or employed in war-time industries or in greatly stimulated industrial activities in the years immediately following these wars. As a result of these conditions farm wage rates were greatly increased over pre-war levels. Moreover, new lands were available for agricultural purposes in both war periods. In the Civil War period the great central prairies were being settled and in the World War period, wheat production especially was increasing in the western Great Plains and other sub-humid areas. The availability of new lands has been a factor which has stimulated the tendency toward increased machinery use.

Although the future trend in machinery use cannot be forecast with any great degree of accuracy, it appears that future development rests largely on the degree of recovery of American industry and the volume of output from our farm plant which will find a foreign outlet.